Response of Bread Wheat (*Triticum aestivum* L.) to Sulfur Rates under Balanced Fertilization at Basona Worena District, North Shewa Zone, Amhara Region, Ethiopia

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Abstract

Sulphur (S) is becoming an important limiting nutrient to agricultural production in Ethiopian soil. The field experiment was conducted for consecutive three years (2013/14-2015/16) to evaluate effects of S levels on yield and yield components of bread wheat grown on two soil types (Cambisols and Vertisols), North Central of Ethiopia. An experiment consisting of six levels S (0, 10, 20,30,40 and 50 kg ha^{-1}) laid out in RCB design with three replications. Results revealed that, yield components were not affected by different levels of S while, yield of wheat were significantly affected by S in both soil types. S applied on cambisols at 30 and 40 kg ha^{-1} increased grain yield (GY) of wheat by 9.0 and 10.1 % over control respectively. The corresponding increases on Vertisols were 8.0 and 10.0 % over control respectively. Application of 10 and 30 kg S ha^{-1} produced the highest marginal rate of return (MMR) (4913.31 and 1277.24%) respectively. The current finding presents additional evidence to research claims that S is becoming a limiting nutrient in some Ethiopian soils. Application of 10 and 30 kg S ha^{-1} are found to be the most economically feasible treatments for bread wheat production in Cambisols and Vertisols of the district respectively.

Keywords: Balanced fertilization, *Cambisols*, Sulfur, *Vertisols*

Introduction

Bread wheat (*Triticum aesativum* L.) is one of the most important cereal crops produced and consumed in Ethiopia. It stands third among cereals in terms of area cultivated annually and grain production next to barley and tef (CSA, 2016). Traditionally, wheat grains are used to prepare household bread, beverage and pancake. It is also processed in factories to produce flour for commercial production of bread for consumers in cities and towns. Despite its importance and growing demand for bread wheat in Ethiopia, its production and productivity are desperately very low. The current average productivity of wheat is below 3 t ha^{-1} (CSA, 2016) despite its potential productivity greater than 5tha^{-1} (Birhan *et al*., 2016). Consequently, the country imports large amounts (30-50% of total annual demand) wheat grains every year from abroad to meet domestic demand (Minot *et al*., 2015) which has grave consequence on foreign currency reserve of the country.

Declining soil fertility is one of the major factors that accounts for low productivity of wheat in Ethiopia (Yesuf and Duga, 2000; Amsal *et al*., 1997) which is caused by soil erosion, continuous cropping of same land year after, deforestation, depletion of organic matter is the main challenge not only to wheat production but also to the production of all crops (Birhan *et al*., 2016). It is an issue of great concern in Ethiopia as soil nutrient depletion is becoming severe and severe with time since little efforts are being made to reverse the problem.

There were several occasions whereby the yields of crops produced per unit area were increased by more than 100 % in many areas of Ethiopia (Kelsa *et al*., 1992). For example, Gebreyes (2008) reported that application of 92 kg nitrogen (N) ha^{-1} increased grain yield of wheat by 185 % over the control in central Ethiopia. Thus, due to dramatic positive impact, there was a steady increase in annual fertilizer consumption from 14000 million tons (mt) in 1974/75 to 500, 000 mt in 2010 (IFPRI, 2012). However, crop yield gain due to N and phosphorus (P) fertilizer application is declining over time despite steady increases in fertilizer consumption in Ethiopia (IFPRI, 2010). Declining crop yield responses to N and P fertilizers is attributed to decreasing soil organic matter (SOM) content (IFPRI, 2010). Moreover, depletion of other nutrients in addition to N and P could be additional factor for decreasing response of crops to N and P fertilizers (Wassie and Tekalign, 2013).

Sulphur (S) could be one of the most likely limiting nutrients in Ethiopia soils. Sulphur is one the plant essential nutrients required for their growth and developments and a building block of protein, key ingredient in the formation of chlorophyll (Duke and Reisenaue, 1986). It plays important role in protein synthesis as it is the component of two essential amino acids called cysteine and methionine. It is also a key component of many enzymes in plants. For instances, the S is important component of nitrogenase enzyme, an enzyme that fixes atmospheric nitrogen in legume-rhizobia biological nitrogen fixation system. Sulphur also interacts with nutrients in soils and the interaction could be positive or negative depending on several factors. For example, Aulakh and Chhibba (1992) observed enhanced root uptakes of P and S when both nutrients were supplied at low rates. Increased uptake and assimilation of N by crops has reported by with adequate than low supply of S (Kumar *et al*., 2012). Thus, deficiency of S in soils will have adverse consequences on protein synthesis, biological nitrogen fixation, chlorophyll synthesis, enzyme activity etc. ultimately compromising yield and quality of crops. It has been reported that S deficient plants exhibits reduced plant height and stunted growth, reduced tillers, spikelets and delayed maturity. Sulfur deficient plants are shown to be less resistance under stress conditions (Doberman and Fairhurst, 2000).

In this regards, emerging research evidences are showing that S one of the nutrients becoming deficient in some Ethiopian soils limiting crop production. For instance, Assefa (2016) studied the response of wheat to S application on 18 sites reported that wheat significantly responded to S fertilizer application in 72 % of experimental sites. He further reported that soils of responding sites had S content below critical level (11-13 mg kg^{-1} SO_4^{-2}-S) for optimum production of wheat.

However, the current assertion that S is becoming nutrient in some Ethiopia soils is based on results of

soils are deficient in S. Thus, further research is needed to be done to verify the existing claims that S limiting in Ethiopian soils in different soil types. In this regard, there is little or no information so far on the response of wheat to S application in Basona worena district of north Shewa, Ethiopia. Thus, experiment was conducted to determine effects of S application under balanced fertilization on the growth, yield components and yield of wheat and to

Basona werna District under two soil types of *Vertisols* and *Cambisols*.

Materials and Methods

Description of the study areas

The experiment was conducted for 3 consecutive years (2013/14-2015/16) cropping season on two locations at Goshebado (*Vertisols*) and Gudoberet (*Cambisols*) about 147 and 172km northwest, and East from the capital City of Ethiopia (Addis Ababa) respectively. Geographically, the field experiment was conducted at a range of 09^0 ^{0}

^{0,} ^{0}

Goshebado and 09^0 ^{0} ^{0} o 039^0

and an altitude of 2914 to 3043 m.a.s.l at Gudoberet. The study locations (soil types) and the district as a whole are characterized by having a uni-modal rainfall pattern and receives an average annual rainfall of 921.2 mm. *Vertisols* is the dominant soil type that the experiment conducted at Goshebado and *Cambisols* at Gudoberet. Major crops grown in both locations; wheat, Barley, lentil, faba bean, and chickpea, field pea and grass pea in decreasing orders of area cultivated under these crops.

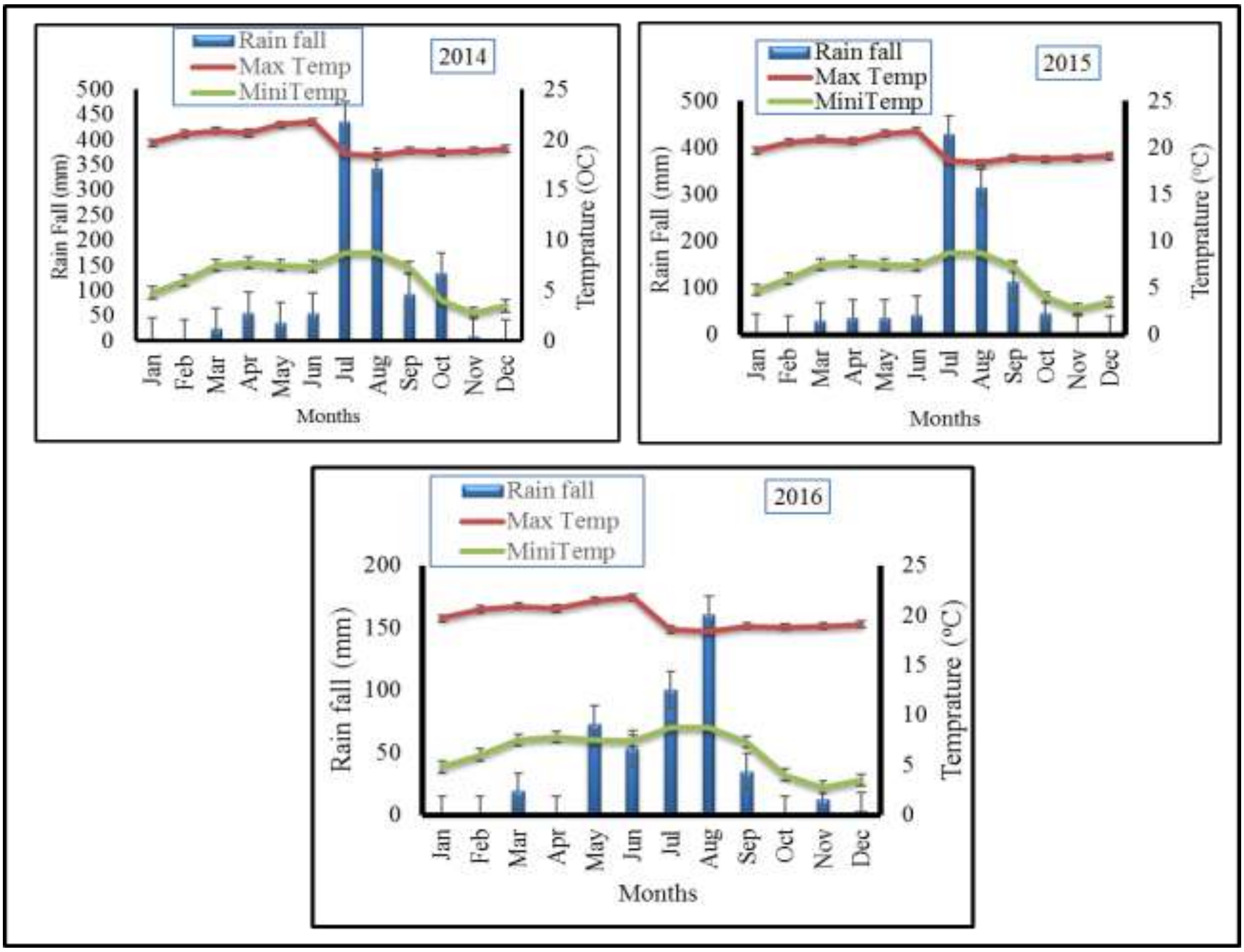

Figure 1. Monthly rain fall and average maximum and minimum temperatures in the three years of the study district

Soil sampling and analyses

After selecting the experimental sites, pre-planting soil samples were collected from each site for the analyses of selected physicochemical properties. Composite soil samples were taken from each site from a depth of 0-20 cm using augur randomly from 15 spots by walking in a zigzag pattern. After thoroughly mixing the composite samples, 1 kg of sub-sample was taken and brought to Debre Birhan agricultural research Centre soil laboratory where it was air dried and grounded to pass 2 mm mesh sized sieve.

The processed samples were analysed for texture following by Bouyoucous hydrometer method (Bouyoucous, 1962). The pH of the soil was measured using pH-water method by making soil to water suspension of 1: 2.5 ratio and was measured using a pH meter. The soil OC content was determined by wet digestion method (Walkley and Black, 1934). Total nitrogen (TN) was determined by using the modified micro Kjeldhal method (Cottenie, ed

by Olsen *et al*. (1954).

Treatments, design and experimental procedure

The experiment consisting of six levels of S (0, 10, 20, 30, 40 and 50 kg ha^{-1}) accompanied by 69P_20_5,80k_20, 92N and micronutrients (2Zn, 0.5Cu and 0.5B kg ha^{-1}) and was laid out in RCB design with three replications. Gypsum (CaSO4*2H2O), Borax, Zinc Sulfate, Copper Salfate and Triple super phosphate (TSP) were used as S, B, Zn, Cu and P sources respectively. The test crop, wheat variety, Diglo was planted in a unit plot size of 3.6 x 3.4m with row spacing of 20 cm apart at a rate of 131.25 kg ha^{-1}. The whole doses of gypsum, KCl and TSP fertilizers were applied as basal in both sides of rows just before planting as per the treatment. The Urea-N was split in which one half of N was applied at planting and the remaining one half was applied one month after planting and after weeding. Micronutrients (Zn, B, and Cu) in the form of ZnS04, Borax and CuS04 respectively was applied foliar mode two times at tillers developments stage of the crops. All agronomic management of the trails were done as per the specific recommendation for the crop.

Data analysis

The collected data were subjected to statistical analysis of variance (ANOVA) and carried out using SAS software program using SAS version 9.3 (SAS institute Inc, 2011). Normality and homogeneity of variance were checked and Combined analysis for the 3 years were done by using the procedure of SAS software version 9.3 (SAS institute Inc, 2011). Mean comparisons were done by Least Significant Difference (LSD) according to gypsum fertilizer during planting of this experiment was collected from Debire Birhan town. Accordingly, price of gypsum was 1.2 Ethiopian birr (ETB) kg^{-1}. The field prices of grain and straw yield at the district local market around the study area was used. Accordingly, prices of grain and straw yield of wheat were 10.5 and 2.4 ETB kg^{-1} respectively.

Results and Discussion

Soil physical and Chemical properties

Pre-planting soil analyses data of selected physicochemical properties of samples collected from experimental locations at Goshebado (*Vertisols*) and Gudoberet (*Cambisols*) are summarized in Table 1. The soils of Goshebado and Gudoberet was belonging to clay textural class. Goshebado soil has soil reaction is ranged from moderately acidic to neutral whereas the soil of Gudoberet is ranged from slightly acidic to neutral reaction (Murphy, 1968). The OC and TN content of both soil types are in low categories according to Tekalign (1991). The available P content of Gudoberet (*Cambisols*) is medium range while at Goshebado (*Vertisols*) is ranged from *very low* to *low* categories (Olsen *et al*., 1954). The available soil P value for crop production and yet it is far lower than the critical soil available P value established for some Ethiopian soils which is 8 mg kg^{-1} (Tekalign and Haque, 1991).

Table 1. Soil physico-chemical properties of the study sites across years

Parameters	*Cambisols*			*Vertisols*		
	2014	2015	2016	2014	2015	2016
pH (1:2.5) ratio	6.2	6.7	6.5	7.15	7.2	5.9
Av. P (ppm)	5.04	7.76	6.06	8.7	0.12	0.42
TN (%)	0.11	0.08	0.08	0.08	0.06	0.06
OC (%)	1.11	0.90	0.91	0.83	0.70	0.70
C: N	10.47	10.81	10.79	11.0	11.5	11.48
Sand (%)	12	16	30	8	12	16
Clay (%)	56	56	42	70	68	70
Silt (%)	32	28	28	22	20	14
Textural Class	clay	clay	clay	clay	clay	clay

Table 2. Mean squares for sources of variation

Parameters	Mean squares for sources of variation with respective degrees of freedom in parenthesis							
	S (5)	Y (2)	SL (1)	Rep in SL (2)	S*Y (10)	S*SL (5)	S*Y*SL (20)	Error (70)
PH	5.9^{ns}	1267.7^{**}	6198.6^{**}	20.2	7.1^{ns}	4.2^{ns}	5.0^{ns}	19.0
SPL	0.05^{ns}	13.30^{**}	32.34^{**}	0.24	0.03^{ns}	0.04^{ns}	0.03ns	0.24
NT	0.13^{ns}	1.91^{**}	97.28^{**}	0.60	0.10^{ns}	0.15^{ns}	0.10ns	0.26
FT	0.2^{ns}	1.60^{**}	124.8^{**}	0.4	0.1^{ns}	0.1^{ns}	00.10ns	0.23

GY	209145*	10193262**	50311170**	101528	11803ns	802 41ns	120442ns	779140
STY	515449*	18621526**	57295361**	19410	62392ns	42210ns	48378ns	2049051

PH =plant height (cm), SPL =spike length (cm), NT= number of total tillers, FT= fertile tillers, GY= grain yield, STY straw yield, S=Sulfur, Y=year, SL=Soil type.

Effect on growth and yield components of Wheat

On soil types, growth and yield components of bread wheat (Table 2). Data in table 3 showed that effects of S on mean growth and yield components of wheat at both Soils types

Table 3. Effect of S on growth and yield components of Wheat at Goshebado (*Vertisols*) and Gudoberet (*Cambisols*)

S-rate (kg ha^{-1})	*Cambisols*				*Vertisols*			
	PH	**SPL**	**NT**	**FT**	**PH**	**SPL**	**NT**	**FT**
0	88.4	6.3	4.9	4.8	73.5	5.4	2.9	2.7
10	90.6	6.4	5.1	5.0	74.4	5.4	2.9	2.6
20	88.8	6.5	4.7	4.7	74.5	5.3	2.9	2.6
30	89.2	6.5	4.9	5.0	75.4	5.4	3.1	2.8
40	90.0	6.4	4.8	4.8	74.0	5.2	3.0	2.8
50	90.1	6.5	4.9	4.9	74.5	5.4	3.2	2.9
CV (%)	**4.3**	**3.5**	**9.2**	**9.7**	**1.8**	**4.1**	**7.4**	**9.1**
LSD (<0.05)	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**

PH=plant height (cm), SPL=spike length (cm), NT=number of total tillers plant^{-1}, FT=fertile tillers plant^{-1}

Table 4. Interaction effects of S with year on growth and yield components of wheat

S-rate (kg ha^{-1})	**2014**				**2015**				**2016**			
	PH	**SPL**	**NT**	**FT**	**PH**	**SPL**	**NT**	**FT**	**PH**	**SPL**	**NT**	**FT**
0	75.5	5.2	4.3	3.9	81.7	6.0	4.0	3.9	85.7	6.3	3.5	3.3
10	74.9	5.3	4.3	4.0	83.8	6.1	3.9	3.9	88.6	6.4	3.9	3.7
20	75.3	5.1	4.1	3.8	83.1	6.2	3.7	3.7	86.4	6.5	3.7	3.5
30	75.3	5.3	4.2	4.0	84.8	6.2	3.9	3.8	86.8	6.3	3.9	3.7
40	75.6	5.2	4.2	4.0	85.2	6.0	3.9	3.9	85.3	6.3	3.7	3.6
50	74.9	5.2	4.2	4.0	85.3	6.2	4.2	4.2	86.8	6.4	3.8	3.5
LSD (<0.05)	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**	**ns**

PH=plant height (cm), SPL=spike length (cm), NT=number of total tillers plant^{-1}, FT=fertile tillers plant^{-1}, S=Sulfur

Table 5. Interaction effects of S with soil types and year on plant height and Spike length of Wheat

Year	Soil Types	Plant height (cm)						Spike Length (cm)					
		S-rate kg ha^{-1}						S-rate kg ha^{-1}					
		0	10	20	30	40	50	0	10	20	30	40	50
1	***Vertisols***	67.1	66.2	67.2	68.5	67.7	66.0	4.9	5.0	4.8	4.9	4.8	4.8
	Cambisols	83.9	83.7	83.4	82.1	83.5	83.8	5.5	5.7	5.5	5.6	5.6	5.7
2	***Vertisols***	71.8	74.1	73.7	73.9	73.7	74.8	5.0	5.0	5.1	5.2	4.9	5.2
	Cambisols	91.6	93.6	92.6	95.6	96.6	95.7	7.0	7.1	7.2	7.2	7.2	7.2
3	***Vertisols***	81.7	82.8	82.5	83.7	80.5	82.7	6.2	6.3	6.2	6.0	6.0	6.3
	Cambisols	89.7	94.3	90.3	90.0	90.0	90.9	6.4	6.6	6.8	6.6	6.5	6.6
LSD(<0.05)		**ns**						**ns**					

1=2014, 2=2015,3=2016

Table 6. Interaction effects of S with soil types and year on number of total and fertile tillers of wheat

Year	Soil Types	Number of total tillers plant^{-1}						Number of fertile tillers plant^{-1}					
		S-rate (kg ha^{-1})						S-rate (kg ha^{-1})					
		0	**10**	**20**	**30**	**40**	**50**	**0**	**10**	**20**	**30**	**40**	**50**
1	***Vertisols***	3.6	3.2	3.5	3.5	3.6	3.5	3.2	2.9	2.9	3.0	3.3	3.1
	Cambisols	5.0	5.3	4.7	4.8	4.7	4.9	4.7	5.1	4.7	5.0	4.7	4.9
2	***Vertisols***	2.4	2.4	2.4	2.5	2.5	3.1	2.3	2.4	2.3	2.4	2.5	3.0
	Cambisols	5.5	5.4	5.0	5.3	5.3	5.3	5.5	5.4	5.0	5.3	5.3	5.3
3	***Vertisols***	2.8	3.0	2.8	3.2	3.0	2.9	2.5	2.7	2.5	2.9	2.8	2.5
	Cambisols	4.2	4.7	4.6	4.6	4.5	4.6	4.1	4.7	4.6	4.6	4.5	4.5
LSD(<0.05)		**ns**						**ns**					

1=2014, 2=2015,3=2016

Effect on yield of Wheat

Both grain yield (GY) and straw yield (GY) of wheat were significantly affected by effects of S application in both *Cambisols* and *Vertisol*s (Table 2). Data in Table 7 showed that effects of S on mean Grain and Straw yield of wheat at both Soils types. On *Cambisols*, increase in S rate up to 30 kg S ha ^{1}) had a positive effect on grain and Straw yield of wheat while above 30 kg S ha^{-1}, yield decreased numerically, but not significantly. Application of 20 and 30 kg ha^{-1} S have significantly increased grain yield by 9.0 and 10.1 % over the control respectively and Straw yield by 10.4 and 10.5 % over control respectively. Similarly, on *Vertisols*, 30 and 40 rates have significantly increased grain yield by 8.0 and 10.0 % over control respectively and same treatments increased Straw yield by 10.6 and 9.0 % over control respectively. Generally, applications of S on both soil types improve grain and straw yield of bread wheat. These results are in agreement with the finding of Assefa Menna (2016) who studied the response of wheat to S application and reported that wheat significantly responded to S fertilizer application. In another study, Khan et al. 2015) reported that S applied at 20 kg ha^{-1} at stem elongation stage significantly increased yield of wheat by 28.5 % over untreated control. According to DeRuiter and Martin 2001), wheat yield can be increased up to 42 % due to S fertilizer depending on the inherent S level in particular soils.

Table 7. Effect of S on mean yield of Wheat on *Vertisols* and *Cambisols*

S-rate (kg ha^{-1})	Grain yield (kg ha^{-1})		Straw yield (kg ha^{-1})	
	Vertisols	*Cambisols*	*Vertisols*	*Cambisols*
0	2438.1c	3635.9c	3421.2b	4771.9b
10	2460.7c	3961.6a	3666.6a	5270.2a
20	2502.8bc	3992.0a	3734.1a	5323.0a
30	2649.2ab	4062.6a	3827.0a	5333.9a
40	2707.3a	3929.6c	3760.4a	5101.7a
50	2572.8abc	3909.5c	3726.0a	5174.7a
CV (%)	**6.1**	**9.6**	**7.0**	**9.4**
LSD (<0.05)	**144.2**	**358.5**	**243**	**462.2**

Table 8. Interaction effects of S with soil types and year on grain and straw yield of wheat

Year	Soil Types	Grain yield kg ha^{-1}						Straw yield kg ha^{-1}					
		S-rate kg ha^{-1}						S-rate kg ha^{-1}					
		0	**10**	**20**	**30**	**40**	**50**	**0**	**10**	**20**	**30**	**40**	**50**
1	***Vertisols***	2009.4	2047.1	2000.4	2208.1	2440.3	2062.6	2926.9	3139.4	3078.4	3241.3	3186.0	2938.7
	Cambisols	2938.5	3298.6	3766.6	3357.0	3142.4	3323.8	4745.0	5044.5	5286.2	5263.9	5151.4	5121.4
2	***Vertisols***	1651.3	1397.1	1539.6	1715.7	1602.3	1648.3	1771.9	1813.7	1900.7	2006.7	1844.4	1902.6
	Cambisols	4636.0	4560.7	4674.6	5162.4	4920.8	4981.6	5656.5	5900.8	6146.4	6276.6	5806.5	5981.0
3	***Vertisols***	3653.6	3937.9	4000.3	3933.8	4079.4	4007.4	5564.9	6046.6	6223.0	6233.0	6250.8	6336.6
	Cambisols	3333.3	4025.5	3534.6	3668.3	3725.5	3423.2	3914.1	4565.2	4537.1	4461.3	4347.2	4421.7
LSD(<0.05)		**ns**						**ns**					

1=2014, 2=2015,3=2016

Effects of Soil and Years

Results of analyses of wheat response data to over all of the two soils and years are summarized in Table 9. Soils and years have significantly affected PH, SPL, NT, BY, GY and STY of wheat. Accordingly, significantly higher values of these parameters were obtained in *Cambisols* than *Vertisols*. *Cambisols*, GY and STY were higher by 34.9 and 28.3% over that produced than *Vertisols* irrespective of treatments. This could be possible due to better nutrient availability to crop in *Cambisol*s than *Vertisols*.

Table 9. Overall mean on growth, yield components and yield of wheat across soils and years

Soil	PH	SPL	NT	FT	BY	GY	STY
Cambisols	89.5a	6.4a	4.9a	4.8a	9061.1a	3915.2a	5145.9a
Vertisols	74.4b	5.3b	3.0b	2.7b	6239.4b	2550.2b	3689.2b
LSD (<0.05)	1.67	0.19	0.196	0.18	869.5	337.93	548.02
Year							
1	75.3c	5.2c	4.2a	4.0a	6807.2b	2713.6c	4093.6b
2	84.0b	6.1b	3.9b	3.9b	7124.9b	3207.5b	3917.3b
3	86.6a	6.4a	3.6c	3.6c	9018.7a	3776.9a	5241.8a
LSD (<0.05)	**2.0**	**0.2**	**0.2**	**0.2**	**1064.9**	**413.9**	**671.2**

PH = plant height (cm), SPL = spike length (cm), NT = number of total tillers plant^{-1}, FT = fertile tillers plant^{-1}, BY = biomass yield (kg ha^{-1}), GY = grain yield (kg ha^{-1}), STY = Straw yield (kg ha^{-1}), 1 = 2014, 2 = 2015, 3 = 2016.

Economic Analyses

The results of partial budget analyses data of S fertilizers across two soils are summarized in Table 10. Accordingly, all treatments produced higher and positive net benefit (NB) relative to the control treatment in both soil types, indicating that feasibility of S fertilizer application for wheat production in the study area. In general, NB from application of S fertilizer produced from *Cambisols* was higher than *Vertisols*. Consequently, the highest NB (42884.9 and 27074.7 ETB) was produced by application of S at 30 and 40 kg ha^{-1} on *Cambisols* and *Vertisols* respectively. When it comes to the marginal rate of return (MRR), the highest value of MRR (4913.31 and 1277.24%) was produced by S at a rate of 10 and 30 kg ha^{-1} from *Cambisols* and *Vertisols* respectively.

Table 10. Partial budget analysis of wheat to the study areas

S-rate (kg ha^{-1})	AGY (kg ha^{-1})	ASTY (kg ha^{-1})	TGB	TVC	NB	MRR	MRR (%)
				Cambisols			
0	3635.9	4771.9	44175.7	5334	38841.7	-	-
10	3961.6	5270.2	48302.9	5418	42884.9	49.13	4913.31
20	3992.0	5323.0	48703.2	5501	43202.2	27.11	2711.08
30	4062.6	5333.9	49364.8	5584	43780.8	20.76	2075.62
40	3929.6	5101.7	47610.5	5668	41942.5	10.28	1028.38
50	3909.5	5174.7	47604.8	5751	41853.8	8.22	D
S-rate (kg ha^{-1})				***Vertisols***			
0	2438.1	3421.2	30153.8	6016	24137.8	-	-
10	2460.7	3666.6	30946.1	6091	24855.1	10.56	1056.45
20	2502.8	3734.1	31487.0	6166	25321.0	8.89	888.83
30	2649.2	3827.0	33027.6	6241	26786.6	12.77	1277.24
40	2707.3	3760.4	33390.7	6316	27074.7	10.79	1078.95
50	2572.8	3726.0	32097.6	6391	25706.6	5.18	D

AGY=Adjusted grain yield, ASTY=adjusted straw yield, TGB=total growth benefit, TVC=total variable cost, NB=net benefit, MRR=marginal rate of return.

Conclusion and Recommendation

The results of this experiment revealed that application of S fertilizer has significantly increased yield of bread wheat grown in *Cambisols* and *Vertisols* of the study district, northern Shewa, Ethiopia compared to that obtained from unfertilized control. Moreover, the current finding presents additional evidence to research claims that S is becoming a limiting nutrient in some Ethiopian soils which being reported. Maximum yield of wheat was obtained with treatment involving application of 30 kg S ha^{-1} and 40 kg S ha^{-1} from *Cambisols and Vertisols* respectively. While, partial budget analysis result revealed that, 10 and 30 kg S ha^{-1} produced the highest MMR (4913.31 and 1277.24%) and thus, those treatments are found to be economically feasible treatments for bread wheat production in *Cambisols* and *Vertisols* of the district of Basona worena respectively.

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